

Basic FM Synthesis

on the

Yamaha DX7

by

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Introduction

This booklet was written to help students to learn the basics of linear FM synthesis and to better understand the Yamaha DX/TX series synthesizers. It is not intended to be a complete course of study on either FM synthesis or the DX7. There are already several very comprehensive books plus a fairly substantial users' manual that provide a mountain of information. The Complete DX7, by Howard Massey, for instance, assumes no prior knowledge or experience in anything related to synthesis. It is a good, fairly comprehensive "self-teach" method book for a rank beginner. As such, it is a lot to wade through if you are not a beginner. This book is aimed at those students who do have some degree of knowledge about conventional analog and subtractive synthesis and assumes at least a passing acquaintance with the DX7 itself--such as can be acquired in a couple of hours spent with the manual and the instrument. It is meant to be used with the manual (and/or an instructor), not as a substitute.

A significant aspect of this instruction manual is its use of OpCode's Editor/Librarian software for the Macintosh computer. With it, one can see at once all of the data for a given voice. Screen-dumps from the program, incorporated in the text, are shaded to draw attention to the pertinent data. If a Macintosh and this software, and appropriate MIDI interfaces are available (and if you first master a couple of basic Macintosh conventions and keep OpCode's user manual nearby for reference), this booklet will help you acquire some fluency with the program as you learn about the principles underlying the DX7's method of timbre production. It is quite possible to learn from these pages without a Macintosh, by accessing the tutorial voices directly from a RAM cartridge which contains the voices and by performing these exercises using the buttons and LCD display of the DX7.

This instructional package is still in its developmental stages. Your comments, compliments, criticisms, and encouragements are welcome.

Note:

In voices where performance functions are relatively unimportant, the box in the diagram with "OK" written in it will appear shaded. For these voices, you need not worry much about performance data. In voices where these functions are important, the "OK" box will be unshaded, indicating that a significant aspect of the demonstration timbre will be affected by one of the four controllers (generally the Modulation Wheel or the Foot Control.)

Special note to Macintosh users:

These tutorial voices were programmed as TX voices so that function data could be incorporated in them. Be sure to select "Yamaha TX" on the menu when you launch the program. Be sure also that there are three menu items under the "Load/Send" menu that have a √ beside them: "Send on Select" (so when you point and click on a voice it will automatically be sent to the Edit Buffer of the DX7 so you can hear it), "Send Perf. to DX7" (to facilitate handling voices that need changes in performance data in order to work properly), and "DX7/DX1/DX5 Voices." Be sure that the DX7 is set up to receive data from the Macintosh. This means that the DX7 must have its Internal Memory "Unprotected" and System Information must be "Available". (Press the brown FUNCTION button, then press button "8" repeatedly until the message SYS INFO UNAVAIL appears, next press the "YES" button.) Both the DX7 and the Macintosh must also agree on the MIDI channel.

DX7 IIFD Users:

See Addendum at the end of this booklet.

1: FM Demo 1-A

(E.G. Control of Timbre)

General Description:

This voice is designed to imitate the familiar analog synthesis sound of slowly opening and closing a low-pass filter. Since the DX-7 has no filters, this subtractive synthesis sound must be obtained in a completely different method: by linear frequency modulation (FM) using a dynamic index of modulation. In other words, we will modulate the carrier sine wave with a second sine wave that varies in amplitude over a given time.

- As the amplitude of the modulator increases, the sound gets brighter (analogous to opening a filter).
- As the amplitude of the modulator decreases the sound gets darker (analogous to closing a filter).

Patch Information:

Operator 1 modulated by Operator 2; both at maximum output; both at same frequency ratio (i.e. both producing the identical frequencies when any given key is pressed); E.G. 2 controls timbre change.

Exercises:

1. Experiment with various frequency ratios for both the operators, especially that of the modulator (Op. 2). Begin with various “Coarse” settings between .5 and 4 or 5. After you begin to understand the timbral changes that result, try widening the range and incorporate also some changes in the “Fine” settings.
2. Experiment with the Output Level of Op. 2 (settings from 60 - 99 will give audible results)

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>	
EGRate		29 38 99 99					
EGLev		99 0 0 0					
Scaling							
Curve							
Output Level	99 Vel RSc AM 0 0 0	99 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	
Freq	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	
PEGRat	99 99 99 99	LFOWave Spd Del PMD AMD PMS Sync				File: DX-7 Demos	
PEGLev	50 50 50 50	Triangl	0 0 0 0 0	0n	1: FM-Demo 1A		
	MIDI	TstKV					1 64
Algorithm	1 Operator 2 Envelope		Rate 99 <input checked="" type="checkbox"/> Rate 0 <input type="checkbox"/>				
KeyTP	C3						
Feedback	0						
KeySync	On						

2: MW-Demo 1

(Mod Wheel Control of Timbre)

General description:

This voice is also designed to imitate the familiar analog synthesis sound of opening and closing a low-pass filter. The difference between this voice and the previous one is that the timbral changes are not automatic, but are controlled in real time by the performer using the Modulation Wheel. (Refer to the previous FM-Demo 1A.)

- As you rotate the Mod Wheel away from you, the amplitude of the modulator increases and the sound gets brighter (analogous to opening a low-pass filter).
- As you rotate the Mod Wheel towards you, the amplitude of the modulator decreases and the sound gets darker (analogous to closing a low-pass filter).

Note: If the Modulation Wheel does not cause the timbre to change in a manner similar to FM-Demo 1-A, see **Additional Help** on the adjacent page.

Exercises:

Try duplicating the Mod Wheel's control of Op. 2 using another controller (i.e. the Foot Pedal, or the After Touch. If you are using the Macintosh, simply click on the "EDIT" button, then select "Send Functions to DX-7" and "Edit Settings" under the "Function" menu. You can then edit the settings with standard Macintosh techniques. You must "Exit" (under the "File" menu) and click on the "EDIT" button or reselect the same voice in order for your new Controller information to be transferred. You can also change the controller information by running through the nine steps listed in the **Additional Help**, but substituting the buttons 21-24 or 29-32 for buttons 17-21 on the right side of DX-7.

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>																									
EGRate	99 99 99 63																														
EGLev	99 99 99 0																														
Scaling																															
Curve																															
Output Level	99 Vel RSc AM 0 0 0	99 Vel RSc AM 0 0 3	0 Vel RSc AM 0 0 0																												
Freq	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0																									
PEGRat	99 99 99 99	LFOWave Spd Del PMD AMD PMS Sync	File: DX-7 Demos			MIDI TstKV																									
PEGLev	50 50 50 50	Triangl 0 0 0 0 0 On	2: MW-Demo 1			1 64																									
Algorithm	1	<table border="1"> <thead> <tr> <th></th> <th>Range</th> <th>Pitch</th> <th>Ampl</th> <th>EG Bias</th> </tr> </thead> <tbody> <tr> <td>Mod Wheel</td> <td>15</td> <td>Off</td> <td>Off</td> <td>On</td> </tr> <tr> <td>Foot Control</td> <td>8</td> <td>Off</td> <td>Off</td> <td>Off</td> </tr> <tr> <td>Breath Ctrl</td> <td>15</td> <td>Off</td> <td>Off</td> <td>Off</td> </tr> <tr> <td>After Touch</td> <td>8</td> <td>Off</td> <td>Off</td> <td>Off</td> </tr> </tbody> </table>					Range	Pitch	Ampl	EG Bias	Mod Wheel	15	Off	Off	On	Foot Control	8	Off	Off	Off	Breath Ctrl	15	Off	Off	Off	After Touch	8	Off	Off	Off	Mod Wheel EG Bias Off <input type="checkbox"/> <input type="checkbox"/> On
	Range	Pitch	Ampl	EG Bias																											
Mod Wheel	15	Off	Off	On																											
Foot Control	8	Off	Off	Off																											
Breath Ctrl	15	Off	Off	Off																											
After Touch	8	Off	Off	Off																											
KeyTP	C3	Poly/Mono Poly Portamento Attenuation 7 Mode Retain Pitch Bend Range 7 Gliss Off Pitch Bend Step 0 Time 0																													
Feedback	0	OK																													
KeySync	On																														

Additional Help for MW-Demo 1:

For original DX7:

If you are using the Macintosh librarian program, you can select the option "Send Perf. to DX7" under the "Load/Send" menu, then re-select this voice.

If you are still unable to get the Mod Wheel to respond, or if you are not using the Macintosh, then you should perform the following steps. When you have completed these, the parameters from your diagram should be in effect on the DX-7 (i.e. maximum Mod Wheel range, Pitch and Amplitude "OFF", EG Bias "ON").

- 1) Press the brown "Function" button on the left side of the DX-7
- 2) Press button "17" on the right side of DX-7
- 3) Slide the "Data Entry" fader down then push it all the way up
- 4) Press button "18" on the right side of DX-7
- 5) Press the "Data Entry-Off" button on the left side of the DX-7
- 6) Press button "19" on the right side of DX-7
- 7) Press the "Data Entry-OFF" button on the left side of the DX-7
- 8) Press button "20" on the right side of DX-7
- 9) Press the "Data Entry-ON" button on the left side of the DX-7

Note:

If you are using the TX7, TX802, or the DX7II-FD, the function data (i.e. mod wheel, foot controller, etc.) is stored separately with each individual "patch" so there should not be any problems if you are using one of these newer synthesizers.

3. FM Demo 1-B

(E.G. Control of Timbre using Velocity)

General Description:

This voice, too, is designed to imitate the sound of opening and closing a low-pass filter. The difference between this voice and previous ones is that while the timbral changes are automatic as in FM Demo 1-A, the amount of modulation achieved is dependent on how hard you play on the keyboard.

- The harder you hit a key, the more it sounds like FM Demo 1-A.
- The softer you hit a key, the less noticeable the modulation becomes. (It is possible to play softly enough to hear none at all.)

Patch Information:

Nearly identical to FM Demo 1-A, except Op. 2 is velocity sensitive, meaning that the amplitude of the modulating signal is dependent on how fast (how hard) you hit the keyboard.

Exercises:

1. Experiment with various settings of velocity sensitivity from “0” (no sensitivity) to “7” (maximum sensitivity)
2. Experiment with various settings of the Op. 2 EG Rate 1. Macintosh users should experiment with all three methods of editing the envelope: 1) “dragging” 2) typing 3) mouse button w/ arrow

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>
EGRate		29 38 99 99				
EGLev		99 0 0 0				
Scaling						
Curve						
Output Level	99 Vel RSc AM 0 0 0	99 Vel RSc AM 7 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0
Freq	M Coar Fine Det r 1. 00 0					
PEGRat	99 99 99 99	LFOWave Spd Del PMD AMD PMS Sync	File: DX-7 Demos			MIDI TstKV
PEGLev	50 50 50 50	Triangl 0 0 0 0 0 On	3: FM-Demo 1B			1 64
Algorithm	1	Operator 2 Envelope		Op 2 Key Velocity Sens		
KeyTP	C3					
Feedback	0					
KeySync	On					

4. FM Demo 1-C

(E.G. Control of Timbre, with Rate Scaling)

General Description:

This is another voice designed to imitate the sound of opening and closing a low-pass filter. In this voice timbral changes again are automatic and the amount of modulation is fixed, as in FM Demo 1-A. The significant difference is that speed of the "opening" and "closing" (i. e. the EG attack and decay of Op. 2) is dependent on how high or low you play on the keyboard. The lower end of the keyboard will sound more like FM Demo 1-A. Change seems to occur more as a result of accelerating the given envelope (rather than from slowing it down.)

- The higher you play, the faster the modulation sweep.
- The lower you play, the slower the modulation sweep.

Patch Information:

Nearly identical to FM Demo 1-A, except the EG of Op. 2 is subjected to "Rate Scaling" (i.e. set to "5")

Exercises:

1. Experiment with various rate scalings from "0" (no rate scaling) to "7" (maximum rate scaling)
2. Experiment with control of Op. 2 EG Rate 1 and Rate 2 as you did with the FM Demo 1-B . Note that if these rates are too short the effects of rate scaling will be insignificant.

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>
EGRate		29 38 99 99				
EGLev		99 0 0 0				
Scaling						
Curve						
Output Level	99 Vel RSc AM 0 0 0	99 Vel RSc AM 0 5 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0
Freq	M Coar Fine Det r 1. 00 0					
PEGRat	99 99 99 99	LFO Wave Spd Del PMD AMD PMS Sync	File: DX-7 Demos			MIDI TstKV
PEGLev	50 50 50 50	Triangl 0 0 0 0 0 0 On	4: FM-Demo 1C			1 64
Algorithm	1	Operator 2 Envelope	Op 2 Keyboard Rate Scaling			
KeyTP	C3					
Feedback	0					
KeySync	On					

5. FM Demo 1-D

(E.G. Control of Timbre)

General Description:

This voice is also closely related to FM Demo 1-A. The main difference is in the envelope shape of Op. 2, which now has an attack every bit as fast as the carrier (Op. 1). Thus the sound begins with index of modulation at maximum. You no longer hear the "filter opening" aspect of the sound, only the "closing." A similar effect may be achieved on an analog synthesizer using an envelope generator (EG) to control a low-pass filter's cut-off frequency. (Of course the "slowly opening and closing [of] a low-pass filter" in the previous analog models for examples 1-A,-B, and-C could also have been accomplished using an EG--with a slow attack--to control the low-pass filter rather than the implied manipulation of the filter's control dial.)

Patch Information:

Nearly identical to FM Demo 1-A (i.e. Op. 1 modulated by Op. 2; both at maximum output; both at same frequency ratio, etc.), except that EG rate 1 of Op. 2 is set at maximum speed (i.e. 99).

Exercises:

1. Experiment with various frequency ratios for both the operators, especially that of the modulator (Op. 2) — as in FM Demo 1-A.
2. Experiment with the Output Level of Op. 2 (settings from 60 - 99 will give audible results)

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>
EGRate		99 38 99 63				
EGLev		99 0 0 0				
Scaling						
Curve						
Output Level	99 Vel RSc AM 0 0 0	99 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0
Freq	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0			
PEGRat	99 99 99 99	LFOWave Spd Del PMD AMD PMS Sync	File: DX-7 Demos			MIDI TstKV
PEGLev	50 50 50 50	Triangl 0 0 0 0 0 On	5: FM-Demo 1D			1 64
Algorithm	1	Operator 2 Envelope		Rate 99 <input checked="" type="checkbox"/>	Rate 0 <input type="checkbox"/>	
KeyTP	C3					
Feedback	0					
KeySync	On					

6. FM Demo 1-E

Velocity Control of Carrier (i.e. Amplitude)

General Description:

This voice is closely related to FM Demo 1-D. The only difference is that now the voice responds to key velocity. The harder (faster) the key is struck, the louder the sound and vice versa.

Patch Information:

Nearly identical to FM Demo 1-D, except that now the carrier (Op. 1) is set at maximum velocity sensitivity.

Exercises:

1. Experiment with various settings of velocity sensitivity for Op. 2 and Op. 1, both together and independently
2. Experiment with the Output Level of Op. 2

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>
EGRate		99 38 99 63				
EGLev		99 0 0 0				
Scaling						
Curve						
Output Level	99 Vel RSc AM 7 0 0	99 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0
Freq	M Coar Fine Det r 1. 00 0					
PEGRat	99 99 99 99	LFO Wave Spd Del PMD AMD PMS Sync	File: DX-7 Demos			MIDI TstKV
PEGLev	50 50 50 50	Triangl 0 0 0 0 0 On	6: FM-Demo 1E			1 64
Algorithm	1	Operator 2 Envelope		Op 1 Key Velocity Sens		
	99					
KeyTP	C3					
Feedback	0					
KeySync	On					

7. FM Demo 1-F

(E.G. Control of Timbre)

General Description:

This voice is also closely related to FM Demo 1-D. The main difference is in the envelope shape of Op. 2, which now has a perceptibly slower attack. The sound may also be perceived as a sped-up version of FM Demo 1-A. A similar effect would be achieved on an analog synthesizer using an envelope generator (EG) to control a low-pass filter's cut-off frequency. (Probably in combination with some filter regeneration to emphasize the timbral extremes of the sound.)

Patch Information:

Nearly identical to FM Demo 1-D, except that EG rate 1 of Op. 2 is slower

Exercises:

1. Experiment with various frequency ratios for both the operators, especially that of the modulator (Op. 2)--as in FM Demo 1-A.
2. Experiment with the Output Level of Op. 2 (settings from 60 - 99 will give audible results)

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>
EGRate		56 42 99 71				
EGLev		99 60 60 0				
Scaling						
Curve						
Output Level	99 Vel RSc AM 0 0 0	99 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0
Freq	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0			
PEGRat	99 99 99 99	LFO Wave Spd Del PMD AMD PMS Sync	File: DX-7 Demos			MIDI TstKV
PEGLev	50 50 50 50	Triangl 0 0 0 0 0 On	7: FM-Demo 1F			1 64
Algorithm	1	Operator 2 Envelope		Rate 99 <input checked="" type="checkbox"/>	Rate 0 <input type="checkbox"/>	
KeyTP	C3					
Feedback	0					
KeySync	On					

8. FM Demo 1-G

(slower carrier E.G. with faster modulator E.G. affects timbre changes, too)

General Description:

This voice, too, is closely related to FM Demo 1-D. The main difference is in the envelope shape of Op. 1, which now has a perceptibly slower attack. A similar effect might be achieved on an analog synthesizer using an envelope generator (EG) to control the center frequency of a band-pass filter. This effect, achieved with great ease and flexibility on the DX7 compared to many older analog synthesizers, is the basis for a wide variety of sounds from the factory preset "Wasp Sting" to various simulated bowed string attacks.

Patch Information:

Nearly identical to FM Demo 1-D, except that EG rate 1 of Op. 1 is slower

Exercises:

1. Experiment with various frequency ratios for both the operators, especially that of the modulator (Op. 2)--as in FM Demo 1-A.
2. Experiment with the Output Level of Op. 2 (settings from 70 - 99 will give audible results)
3. Experiment with various degrees of rate scaling (RSc) for Op. 1

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>	
EGRate	53 99 99 63						
EGLev	99 99 99 0						
Scaling							
Curve							
Output Level	99	99	0	0	0	0	
	Vel RSc AM	Vel RSc AM	Vel RSc AM	Vel RSc AM	Vel RSc AM	Vel RSc AM	
	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	
Freq	M Coar Fine Det	M Coar Fine Det	M Coar Fine Det	M Coar Fine Det	M Coar Fine Det	M Coar Fine Det	
	r 1. 00 0	r 1. 00 0	r 1. 00 0	r 1. 00 0	r 1. 00 0	r 1. 00 0	
PEGRat	99 99 99 99	LFOWave Spd Del PMD AMD PMS Sync				File: DX-7 Demos	
PEGLev	50 50 50 50	Triangl	0	0	0	0	On
							MIDI TstKV
							1 64
Algorithm	1 Operator 1 Envelope		Rate 99 <input checked="" type="checkbox"/> Rate 0 <input type="checkbox"/>				
KeyTP	C3						
Feedback	0						
KeySync	On						

9. FM Demo 2-A

(E.G. Control of Timbre)

General Description:

While this voice may initially appear to be a duplicate of FM Demo 1-A, when later characteristics of the sound are heard (i.e. when a key is held down for a while, or upon release of the key if it's not held down long), it is clear that there are significant differences. They result primarily from the fact that the envelope for the modulating Op. 2 is inverted--meaning that the beginning and ending are at maximum amplitude, while the internal amplitude is much lower. Fairly slow internal rates allow the changes between the amplitude levels to be quite apparent.

Patch Information:

Basic two operator patch (i.e. Op. 1 modulated by Op. 2; both at maximum output; both at same frequency ratio, etc.), but Op. 2 has an inverted envelope.

Exercises:

1. Experiment with various settings for the envelope of Op. 2. Adjust both the EG Rates and Levels. Try to get rid of the "release sound" by decreasing EG Rate 4 on Op. 2. Use all three methods of editing the envelope: 1) "dragging" 2) typing 3) mouse button w/ arrow
2. Experiment with the Output Level of Op. 2 (settings from 60 - 99 should give audible results)

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>
EGRate		99 38 35 99				
EGLev		99 40 99 99				
Scaling						
Curve						
Output Level	99 Vel RSc AM 0 0 0	99 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0
Freq	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0			
PEGRat	99 99 99 99	LFO Wave Spd Del PMD AMD PMS Sync	File: DX-7 Demos			MIDI TstKV
PEGLev	50 50 50 50	Triangl 0 0 0 0 0 On	9: FM-Demo 2A			1 64
Algorithm	1	Operator 2 Envelope		Rate 99 <input checked="" type="checkbox"/>	Rate 0 <input type="checkbox"/>	
KeyTP	C3					
Feedback	0					
KeySync	On					

10. FM Demo 2-B

(E.G. Control of Timbre)

General Description:

This voice is derived from FM Demo 2-A. It has a similar inverted envelope for Op. 2, but the sustain level is kept low. Thus it is indistinguishable from FM Demo 1-D, with its right-side-up envelope, until a key is released. The "metallic" sound of the release is the characteristic sound and one of the primary uses for inverted envelopes. The various DX7 harpsichord presets all use some version of this device.

Patch Information:

Nearly identical to FM Demo 2-A, except that Op. 2 has a low sustain setting

Exercises:

1. Experiment with various frequency ratios for both the operators, especially that of the modulator (Op. 2)--as in FM Demo 1-A.
2. Experiment with the Output Level of Op. 2 (settings from 60 - 99 will give audible results).
3. Experiment with various degrees of rate scaling (RSc) for Op. 2.

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>
EGRate		99 38 99 99				
EGLev		99 40 40 99				
Scaling						
Curve						
Output Level	99 Vel RSc AM 0 0 0	99 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0
Freq	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0			
PEGRat	99 99 99 99	LFO Wave Spd Del PMD AMD PMS Sync	File: DX-7 Demos			MIDI TstKV
PEGLev	50 50 50 50	Triangl 0 0 0 0 0 On	10: FM-Demo 2B			1 64
Algorithm	1	Operator 2 Envelope		Rate 99 <input checked="" type="checkbox"/>	Rate 0 <input type="checkbox"/>	
KeyTP	C3					
Feedback	0					
KeySync	On					

11. Pitch EG Demo 1

General Description:

This voice is designed to demonstrate obvious (and dramatic) use of the Pitch EG. The DX-7 has only one envelope for pitch control. It affects all operators simultaneously, whether they be carriers or modulators. There is no way to isolate the effects of the pitch envelope on any given operator, nor is there any way to have more than one pitch envelope per voice.

Patch Information:

Op. 2 modulates Op. 1 (both at full output) with a slowly ascending and descending Pitch EG controlling both simultaneously. A Level setting of "50" indicates normal pitch; numbers above "50" indicate a higher pitch; numbers below "50" indicate a lower pitch. The amplitude EG for Op. 2 (the modulator) is set with relatively slow rates so that changes in timbre accompany changes in pitch.

Exercises:

1. Try adjusting the shape of the Pitch EG by drastically changing the first two rates. If you are using the Macintosh, simply "drag" the appropriate corners of the graphic display of the EG. (You may need to "point and click" the mouse on one of the numerical settings of the pitch EG to bring the graphic EG into the editing window.)
2. Make adjustment in the Level settings for the Pitch EG. Begin simply by altering the "non-50" settings. Next start altering the levels set at "50". Finally, try to make the Pitch EG change directions more than two times by alternating levels (i.e. high-low-high-low, etc.)

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>	
EGRate							
EGLev							
Scaling							
Curve							
Output Level	99	99	0	0	0	0	
Vel RSc AM	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	
Freq	M Coar Fine Det						
	r 1. 00 0						
PEGRat	6 13 5 99	LFO Wave Spd Del PMD AMD PMS Sync				File: DX-7 Demos	
PEGLev	60 60 50 50	Triangl 0 0 0 0 0 On				11: Pitch EG 1	
						MIDI TstKV	
						1 64	
Algorithm	1	Pitch Envelope					Rate 99 <input checked="" type="checkbox"/> Rate 0 <input type="checkbox"/>
KeyTP	C3						
Feedback	0						
KeySync	On						

12: Pitch EG Demo 2

General Description:

This is another voice with dramatic use of the pitch envelope. A sine wave moves from a very high pitch to normal pitch ("50") in one smooth descent.

Patch Information:

Op. 1 is the only operator used so the Pitch EG operates only on it. Note that in order for the Pitch EG to start way above normal, Level 4 needs to be up very high. This is the only way to have the sound begin high suddenly. In other words the sound begins where it left off on Level 4 and then proceeds to Level 1 at Rate 1. If you are using the Macintosh, note also that you can not "drag" the far left box of the EG graphic. You must "drag" the Level 4 box, then the left box will move to whatever value you set for Level 4.

Exercises:

1. Try adjusting the shape of the Pitch EG by significantly altering Rate 1 and the Level 4. If you are using the Macintosh, simply "drag" the appropriate corners of the graphic display of the EG. (You may need to "point and click" the mouse on one of the numerical settings of the pitch EG to bring the graphic EG into the editing window.)
2. Increase the Output Level for Op. 2 and make adjustments in its amplitude EG so that the timbre of the voice changes over time as well as its pitch. Try to coordinate the two different types of envelopes to achieve an interesting effect.

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>	
EGRate							
EGLev							
Scaling							
Curve							
Output Level	99 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	0 Vel RSc AM 0 0 0	
Freq	M Coar Fine Det r 1. 00 0						
PEGRat	70 99 99 99	LFO Wave Spd Del PMD AMD PMS Sync				File: DX-7 Demos	
PEGLev	50 50 50 99	Triangl 0 0 0 0 0 On				12: Pitch EG 2	
						MIDI TstKV	1 64
Algorithm	1	Pitch Envelope				Rate 99 <input checked="" type="checkbox"/>	Rate 0 <input type="checkbox"/>
KeyTP	C3						
Feedback	0						
KeySync	On						

13: TM Demo

(LFO Control of Timbre)

General Description:

This voice is designed to imitate the subtractive synthesis sound achieved by filter modulation or timbral modulation (TM). The FM equivalent of this sound is arrived at using a low frequency oscillator (LFO) to control the amplitude of the modulating operator. As we have seen before, changes in the amplitude of the modulating operator result in changes in the overall timbre. In this example, the changes in amplitude are controlled by an LFO.

Patch Information:

LFO controls amplitude modulation of Op. 2, which in turn provides for frequency modulation of Op. 1 (both at full output). Op. 2 response to LFO is effected by the Amplitude setting of the Mod Sensitivity parameter (set to a maximum of "3" in this case--labelled AM on the Macintosh).

Exercises:

1. Experiment with changes in the Amplitude Modulation Sensitivity (settings range from 0-3). Note the "blip" in the sound caused by imposing a limit (settings 1-2) on the range of amplitude variance--the result is a virtual "clipping" of the triangle waveform of the LFO.
2. With the AM sensitivity set on "3", experiment with changes in the Output Level of Op. 2 (from ca. 40-99). Next try varying the output in conjunction with changes in the AM sensitivity.
3. Experiment with various waveforms for the LFO
4. Experiment with changes in the frequency (Speed) of the LFO.

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>					
EGRate											
EGLev											
Scaling											
Curve											
Output Level	99 Vel RSc AM 0 0 0	99 Vel RSc AM 0 0 3	0 Vel RSc AM 0 0 0								
Freq	M Coar Fine Det r 1. 00 0										
PEGRat	99 99 99 99	LFOWave Spd Del PMD AMD PMS Sync				File: DX-7 Demos	MIDI TstKV				
PEGLev	50 50 50 50	Triangl	6	0	0	99	0	On	13: TM-Demo	1	64
Algorithm	1	Pitch Envelope				LFO Amplitude Mod Depth					
	99				0 99					
	75									
	50	■■■■■									
	25									
	0									
KeyTP	C3										
Feedback	0										
KeySync	On										

14: TM Demo-MW

(Mod Wheel determines depth of LFO control of timbre)

General Description:

This voice is also designed to imitate the subtractive synthesis sound achieved by timbral modulation (TM). In this case, the amount of TM can be altered in real time. Specifically, the overall amplitude of Op. 2, as well as the operator's responsiveness to the LFO amplitude modulation, is controlled by the Mod Wheel.

Patch Information:

Similar to the previous TM Demo except that the Mod Wheel is set to have maximum control (setting "15") over Amplitude ("On") and EG Bias ("On"). Only Op. 2 is set to respond to either (by virtue of its AM/"3" setting). Amplitude "On" results in the Mod Wheel controlling the degree of low-frequency AM of Op. 2; EG Bias "On" results in the Mod Wheel controlling all the levels of amplitude EG for Op. 2. (With the Mod Wheel rotated all the way forward the stored EG values for Op. 2 are functional. As the wheel is rotated forward, all the levels are reduced proportionally until they reach "0.")

Exercises: (all exercises should incorporate rotations of the Mod Wheel)

1. Experiment with changes in the Mod Wheel Range. (rotate Mod Wheel)
2. Switch EG Bias to "Off" (rotate MW). Note that the TM sound still fades in and out as you rotate the MW, but that the basic reference timbre is very bright--the result of having the full output of Op. 2 modulating Op. 1 until the LFO is brought into play by the MW.
3. Experiment with changes in LFO frequency (Speed) and waveform.

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>	
EGRate							
EGLev							
Scaling							
Curve							
Output Level	99 Vel RSc AM 0 0 0	99 Vel RSc AM 0 0 3	0 Vel RSc AM 0 0 0				
Freq	M Coar Fine Det r 1. 00 0						
PEGRat	99 99 99 99	LFO Wave Spd Del PMD AMD PMS Sync				File: DX-7 Demos	MIDI TstKV
PEGLev	50 50 50 50	Triangl	8	0	0	0	0
Algorithm	1	Mod Wheel EG Bias				Off <input type="checkbox"/> On <input type="checkbox"/>	
		Range	Pitch	Ampl	EG Bias		
KeyTP	C3	Mod Wheel	15	Off	On	On	
Feedback	0	Foot Control	8	Off	Off	Off	
KeySync	On	Breath Ctrl	15	Off	Off	Off	
		After Touch	8	Off	Off	Off	
		OK		Poly/Mono	Poly	Portamento	
				Attenuation	7	Mode	Retain
				Pitch Bend Range	7	Gliss	Off
				Pitch Bend Step	0	Time	0

15: TM-Organ

General Description:

This voice is designed to show how the basic concept of timbre modulation can be used as part of a more complex, musically interesting sound. It is included here mainly to show what this discussion of simple FM synthesis might lead to once these concepts are mastered. Though this voice is probably more complex than a beginning synthesist might be expected to invent, most of the individual components of the sound construction have already been discussed. What makes this voice complex (and musically satisfying) is the interaction of several individually simple components.

Patch Information:

The "TM" aspect of the sound is caused by LFO amplitude modulation of Op. 2 (which modulates Op. 1). Op. 2 is set for maximum sensitivity to the LFO modulation (see AM/"3" setting). This is similar to the previous two examples. One small but significant difference in the LFO modulation is that LFO "Sync" is turned off in this example. This means that the pattern of LFO modulation occurs independent of keyboard depressions. The keyboard does not trigger the LFO to begin a new cycle, which means that each note played is likely to occur during a different part of the continuously ongoing LFO cycle. Since the LFO is controlling timbre, each note is likely to have a slightly different timbre depending on where in the LFO cycle the key is depressed. Using a moderately gentle touch, tap out a rhythmic pattern on any one note on the lower half of the keyboard. If you look at the parameters for Operators 3-6, you will note that they all have some degree of Velocity Sensitivity programmed into them. The modulators, which we've seen control timbre, have higher sensitivity settings so the harder/faster a key is depressed the brighter the timbre. Including this touch sensitive portion of the voice allows the keyboard player instant control of the timbre that will over-ride the LFO control of the timbre. This gives the player a great deal of expressive flexibility. When you are playing easy unaccented lines and chords the LFO automatically provides subtle changes in timbre (similar to a "Wah-Wah" pedal). When you want to call attention to a note by giving it a brighter timbre simply accent the note. Try articulating a rhythmic pattern on one note in the middle or upper register, but this time use occasional accents. The last touches added to the voice are Level Scaling on Op. 2 and Rate Scaling ("RSc") on Op. 3. The Level Scaling of Op. 2 causes the "TM" effect to be emphasized in the lower register and de-emphasized in the upper register. The Rate Scaling of Op. 3 causes timbral differences in the lower register between accented and unaccented notes to be less pronounced than in the upper register. Experiment with various degrees of accents in different registers on the keyboard and listen for this subtle difference in effect.

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>	
EGRate							
EGLev							
Scaling		28 C3 18					
Curve		+lin -lin					
Output Level	99	86	93	89	66	99	
	Vel RSc AM						
	0 0 0	0 0 3	2 5 0	4 0 0	5 0 0	7 0 0	
Freq	M Coar Fine Det						
	r 1. 00 0						
PEGRat	99 99 99 99	LFOWave Spd Del PMD AMD PMS Sync				File: DX-7 Demos	
PEGLv	50 50 50 50	Triangl	6	0	0	99	0 Off
		15: TM-Organ				MIDI	TstKV
						1	64

Algorithm	1	Operator 2 Keyboard Scaling		R
		L		99+
		+99		
		+50		50+
		+0		0+
		-0		0-
		-50		50-
		-99		99-
KeyTP	C3			
Feedback	0			
KeySync	On			

16: "Wah" Organ

General Description:

This voice is very similar to the previous TM-Organ. The only difference is that the aspect of timbre control previously accomplished automatically by the LFO is now effected by using the Foot Controller. Play several notes on the keyboard in various registers while moving the foot pedal up and down and listen to the effect on the timbre. Note that the timbre is still touch-sensitive in the same general way as the TM-Organ voice.

Note: If you have trouble getting a proper response from the Foot Controller, follow the instructions under the heading **Additional Help for MW-Demo**, but substitute buttons 21-24 for buttons 17-20 respectively. Also — Make sure that the foot controller pedal is connected to the jack on the back of the DX7 labeled “controller” NOT the one labeled “volume”

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>	
EGRate							
EGLev							
Scaling							
Curve							
Output Level	99 Vel RSc AM 0 0 0	86 Vel RSc AM 0 0 3	93 Vel RSc AM 2 5 0	89 Vel RSc AM 4 0 0	66 Vel RSc AM 5 0 0	99 Vel RSc AM 7 0 0	
Freq	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 1. 00 0					
PEGRat	99 99 99 99	LFOWave Spd Del PMD AMD PMS Sync				File: DX-7 Demos	
PEGLev	50 50 50 50	Triangl	6	0	0	0	Off
						MIDI TstKV 1 64	
Algorithm	1				Foot Control EG Bias		
		Range	Pitch	Ampl	Off <input type="checkbox"/> On <input type="checkbox"/>		
Mod Wheel	8	Off	Off	Off			
Foot Control	15	Off	Off	On			
Breath Ctrl	15	Off	Off	Off			
After Touch	8	Off	Off	Off			
KeyTP	C3	Poly/Mono		Poly	Portamento		
Feedback	0	Attenuation		7	Mode Retain		
KeySync	On	Pitch Bend Range		7	Gliss Off		
OK		Pitch Bend Step		0	Time 0		

17: LF Carri 1

General Description:

This voice introduces the concept of using an operator as a sine wave LFO by assigning it a very low fixed frequency. Used as a modulator, this low, fixed-frequency operator could provide an alternative type of vibrato control. In this voice, however, the low-frequency operator functions as a carrier, causing cyclic changes in timbre.

Patch Information:

Op. 1 is set to a frequency of 1Hz, the lowest possible fixed-frequency on the DX7. (The fact that the DX7 does not allow its operators to be fine-tuned between 1 and 0 Hertz is a design flaw that has disappointed many synthesists.) Op. 2 tracks the keyboard and modulates Op. 1 at full output.

Exercises:

1. Experiment with Op. 2 Output Level. Try settings between 50 and 99.
2. Experiment with the Mod Wheel. Note that its effects are simply added onto the low-frequency effects already present.
3. With Op. 2 at whatever Output Level you find pleasing, experiment with Op. 1 frequency changes. To do this, press the OPERATOR SELECT button on the left side of the DX7 repeatedly until the display reads, "OP1" in the upper right corner. Then press the EDIT/COMPARE on the left side of DX7, followed by button "19" (FREQUENCY/FINE) on the right. Listen to the frequency changes as you hold down a chord while you slowly slide the data entry fader up and down. This is one of the few instances where data changes are heard while a key is depressed. (The other buttons controlling oscillator frequency and the buttons for LFO Wave and Speed also respond this way.) Usually the sound is not updated until you press another key down.
4. Return Op. 2 to Output Level 99 and program a Level Scaling on it. To do this in an easy manner, press button "25" (DEPTH) once or twice until the lower left corner has an "R" in it, then slide the data entry fader around until the number in the lower right corner is between 25 and 40. If you are using the Macintosh you can do this even more simply by pointing and clicking on the "0" to the right of the A-1 beneath Op. 2 and simply typing in a number between 25 and 40. The default setting on Level Scaling is a negative linear curve with a break point of A-1 (the lowest A on a piano) which is off the DX7 keyboard. By programming a negative linear curve to the right of that Low-A, you've constructed a sound with a brighter timbre on the lower end of the keyboard.

18: LF Carri 2

General Description/Patch Information:

This voice simply expands on the concepts of the previous voice. The settings for Op. 1 and Op. 2 are identical in both voices. In this voice Op. 3 and Op. 4 are added, with settings that nearly duplicate Op. 1 and Op. 2. The only difference is that the Op. 3 has a different Fixed-Frequency setting.

Exercises:

1. Hold one note down and listen to the complex beating pattern that results from the interaction of the slightly out-of-tune LF Operators. Play several notes one at a time and hold them down. Notice that beating patterns are not in sync with each other, so that each note swells and fades independently of the rest.
2. Make minor changes in Fine Frequency settings for Op. 1 & 3. (repeat 1)

19: LF Carri 3

General Description:

This voice is designed to expand still further on the basic concept of low-frequency carriers. In this voice another pair of operators with an LF carrier is added.

Patch Information:

The settings for Op. 1, Op. 2, Op. 3, and Op. 4 are identical to LF Carri 2. Now, Op. 5 and Op. 6 are included, with settings that nearly duplicate those of the other pairs. The fixed-frequency value for the LF Op. 5 is the only difference. In order for Op. 5 to function as a carrier, algorithm 5 is used for the first time in these studies.

Exercises:

1. Hold one note down and listen to the complex beating pattern that results from the interaction of the slightly out-of-tune LF Operators. Play several notes one at a time and hold them down. Notice that beating patterns are not in sync with each other, so that each note swells and fades independent of the rest.
2. Make minor changes in Fine Frequency settings for Op. 1 & 3. (repeat 1)

On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Mod <input checked="" type="checkbox"/>	5 Car <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>																																								
EGRate																																														
EGLev																																														
Scaling																																														
Curve																																														
Output Level	99 Vel RSc AM 0 0 0	90 Vel RSc AM 0 0 0	99 Vel RSc AM 0 0 0	90 Vel RSc AM 0 0 0	99 Vel RSc AM 0 0 0	90 Vel RSc AM 0 0 0																																								
Freq	M Coar Fine Det f 1.0 00 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det f 1.3 80 0	M Coar Fine Det r 1. 00 0	M Coar Fine Det f 1.2 59 0	M Coar Fine Det r 1. 00 0																																								
PEGRat	99 99 99 99	LFO Wave Spd Del PMD AMD PMS Sync				File: DX-7 Demos	MIDI TstKV																																							
PEGLv	50 50 50 50	Triangl	35	0	0	3	On																																							
Algorithm 5		Mod Wheel Pitch				Off <input type="checkbox"/> On <input type="checkbox"/>																																								
<table border="1"> <tr> <td></td> <td>Range</td> <td>Pitch</td> <td>Ampl</td> <td>EG Bias</td> </tr> <tr> <td>Mod Wheel</td> <td>8</td> <td>On</td> <td>Off</td> <td>Off</td> </tr> <tr> <td>Foot Control</td> <td>8</td> <td>Off</td> <td>Off</td> <td>Off</td> </tr> <tr> <td>Breath Ctrl</td> <td>15</td> <td>Off</td> <td>Off</td> <td>Off</td> </tr> <tr> <td>After Touch</td> <td>8</td> <td>Off</td> <td>Off</td> <td>Off</td> </tr> </table>			Range	Pitch	Ampl	EG Bias	Mod Wheel	8	On	Off	Off	Foot Control	8	Off	Off	Off	Breath Ctrl	15	Off	Off	Off	After Touch	8	Off	Off	Off	<table border="1"> <tr> <td>Poly/Mono</td> <td>Poly</td> <td>Portamento</td> <td></td> </tr> <tr> <td>Attenuation</td> <td>7</td> <td>Mode</td> <td>Retain</td> </tr> <tr> <td>Pitch Bend Range</td> <td>7</td> <td>Gliss</td> <td>Off</td> </tr> <tr> <td>Pitch Bend Step</td> <td>0</td> <td>Time</td> <td>0</td> </tr> </table>				Poly/Mono	Poly	Portamento		Attenuation	7	Mode	Retain	Pitch Bend Range	7	Gliss	Off	Pitch Bend Step	0	Time	0
	Range	Pitch	Ampl	EG Bias																																										
Mod Wheel	8	On	Off	Off																																										
Foot Control	8	Off	Off	Off																																										
Breath Ctrl	15	Off	Off	Off																																										
After Touch	8	Off	Off	Off																																										
Poly/Mono	Poly	Portamento																																												
Attenuation	7	Mode	Retain																																											
Pitch Bend Range	7	Gliss	Off																																											
Pitch Bend Step	0	Time	0																																											
KeyTP	C3	OK																																												
Feedback	0																																													
KeySync	On																																													

20: Addsynth 1

General Description:

This voice is constructed using additive synthesis. With only six sine waves to sum, the DX7 is not a powerful tool for this method of sound construction. But it does provide the basics for using it alone or in combination with FM synthesis. Algorithm 32, with all six operators functioning as carriers, allows maximum additive synthesis power and flexibility.

Patch Information:

In Algorithm 32, all six operators are used as carriers. The Output Level for each is set at the maximum ("99"). Frequency Ratios are set to the ascending whole integers 1, 2, 3, 4, 5, 6, producing the first six harmonics. All other settings, including envelopes, are left at the Voice Initialization default values. (Now you know basically how cheap organs get their sound!)

Exercises:

1. Isolate the sound of each operator by turning off all but one of them at a time. Use the OPERATOR ON/OFF switches on the DX7 (buttons "1-6") or, with the Macintosh, use the mouse to click in the box with the "X" in it (next to the big operator numbers).
2. Experiment with the Output Levels for all the operators.
3. Experiment with the Coarse Frequency Ratios of all the operators, making sure that you set them all to different integers.
4. Experiment with the Fine Frequency Ratios of all the operators. The sounds you are most likely to construct this way will be examples of non-harmonic additive synthesis.

On/Off	1 Car <input checked="" type="checkbox"/>	2 Car <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Car <input checked="" type="checkbox"/>	5 Car <input checked="" type="checkbox"/>	6 Car <input checked="" type="checkbox"/>	
EGRate						99 99 99 99	
EGLev						99 99 99 0	
Scaling							
Curve							
Output Level	99 Vel RSc AM 0 0 0						
Freq	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 2. 00 0	M Coar Fine Det r 3. 00 0	M Coar Fine Det r 4. 00 0	M Coar Fine Det r 3. 00 0	M Coar Fine Det r 6. 00 0	
PEGRat	99 99 99 99	LFO Wave Spd Del PMD AMD PMS Sync				File: DX-7 Demos	
PEGLev	50 50 50 50	Triangl	0 0 0 0 0 0	On		MIDI TstKV 1 64	
Algorithm	32		Operator 6 Envelope			Rate 99 <input checked="" type="checkbox"/>	Rate 0 <input type="checkbox"/>
KeyTP	C3						
Feedback	0						
KeySync	On						

21: Addsynth 2

General Description:

This voice is similar to the previous Addsynth 1. In fact, the steady-state sound of a note that has been held down 3 or 4 seconds is absolutely identical. The only differences occur at the beginning of the sound. The envelope generators are designed so as to bring in each harmonic of the sound separately.

Patch Information:

Identical to Addsynth 1 except for EG settings. Ops. 2-6 all have a rather slow EG Rate 1 (ranging from 7 to 23) which is combined with a Level 1 setting that is too low to be audible. This combination serves to delay the the audible "attack" which is provided by a moderate EG Rate 2 (ca. 50) in combination with a maximum Level 2 setting.

Exercises:

1. Try altering the order of harmonic entrances by adjusting EG Rate 1 on Ops. 2-6. If you "get lost" and want to get back to the original sound to try again, or before going on to Exercise 2, simply recall a fresh copy of the voice to the Edit Buffer. (Select "Compare" under the Edit menu for Macintosh or CARTRIDGE button followed by button "21" on DX7)
2. Experiment with the Coarse Frequency Ratios of all the operators, making sure that you set them all to different integers.
3. Experiment with the Fine Frequency Ratios of all the operators.

On/Off	1 Car <input checked="" type="checkbox"/>	2 Car <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Car <input checked="" type="checkbox"/>	5 Car <input checked="" type="checkbox"/>	6 Car <input checked="" type="checkbox"/>
EGRate	94 99 99 90	23 51 99 90	17 51 99 90	13 51 99 90	10 50 99 90	7 50 99 90
EGLev	99 99 99 0	50 99 99 0	50 99 99 0	50 99 99 0	50 99 99 0	49 99 99 0
Scaling	0 A-1 0					
Curve	-lin -lin					
Output Level	99 Vel RSc AM 0 0 0					
Freq	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 2. 00 0	M Coar Fine Det r 3. 00 0	M Coar Fine Det r 4. 00 0	M Coar Fine Det r 5. 00 0	M Coar Fine Det r 6. 00 0
PEGRat	99 99 99 99	LFO/Wave Spd Del PMD AMD PMS Sync			File: DX-7 Demos	
PEGLev	50 50 50 50	Triangl	0 0 0 0 0	On	MIDI TstKV 1 64	

Algorithm	32	Operator 6 Envelope		Rate 99 <input checked="" type="checkbox"/>	Rate 0 <input type="checkbox"/>
Operator	3 4 6 1 2 5				
KeyTP	C3				
Feedback	0				
KeySync	On				

22: Addsynth 3

General Description:

This voice is similar to the previous Addsynth 2, but this time the entrances of the various harmonics have a stronger, more bell-like attack and are higher pitched than before. The sound also dies away more slowly.

Patch Information:

EG settings similar to Addsynth 2 (Ops. 2-6: Level 1 is ca. 50, Rate 1 ranges from 6 to 23), but now Rate 2 is above 90 (bell-like attack) and all operators have a Rate 4 of 30 (slow decay). Frequency Ratios range from 3 to 8.

Exercises:

1. Try adjusting all the EG Rate 4 settings to cause the harmonics to decay at different rates, becoming inaudible in the same order as their attacks.
2. Assign the same Rate Scaling value to each operator so that time-delays for entrances of the harmonics vary according to the highness or lowness of the key depressed. Try several different "across-the-board" values.

On/Off	1 Car <input checked="" type="checkbox"/>	2 Car <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Car <input checked="" type="checkbox"/>	5 Car <input checked="" type="checkbox"/>	6 Car <input checked="" type="checkbox"/>	
EGRate	94 99 99 30	23 94 99 30	17 94 99 30	13 94 99 30	10 94 99 30	6 99 99 30	
EGLev	99 99 99 0	50 99 99 0	50 99 99 0	50 99 99 0	50 99 99 0	46 99 99 0	
Scaling	0 A-1 0						
Curve	-lin -lin						
Output Level	99 Vel RSc AM 0 0 0						
Freq	M Coar Fine Det r 4. 00 0	M Coar Fine Det r 3. 00 0	M Coar Fine Det r 5. 00 0	M Coar Fine Det r 4. 00 0	M Coar Fine Det r 8. 00 0	M Coar Fine Det r 6. 00 0	
PEGRat	99 99 99 99	LFO/Wave Spd Del PMD AMD PMS Sync			File: DX-7 Demos		MIDI TstKV
PEGLev	50 50 50 50	Triangl 0 0 0 0 0 On			22: AddSynth 3		1 64

Algorithm	32	Operator 6 Envelope		Rate 99 <input checked="" type="checkbox"/>	Rate 0 <input type="checkbox"/>						
<table border="1"> <tr><td>3</td><td>4</td><td>6</td></tr> <tr><td>1</td><td>2</td><td>5</td></tr> </table>	3	4	6	1	2	5					
3	4	6									
1	2	5									
KeyTP	C3										
Feedback	0										
KeySync	On										

23: Addsynth 4

General Description:

This voice is derived from Addsynth 1 and shares an identical steady-state sound with it. The only difference is that the harmonics smoothly, but quickly fade in one by one over a short span of time (ca. 1 sec.). Notice that this effect is very similar to the sound of a low-pass filter controlled by an EG, which in turn we've seen to be similar in effect to the linear FM sounds introduced at the beginning of this book. (i.e. Using an amplitude EG to control a sinewave which then modulates a sinewave carrier.) So we now have 2 utterly different ways of approximating that common subtractive synthesis sound on the DX7.

Patch Information:

Identical to Addsynth 1, except EG Rate 1 settings for Ops. 1-6 descend by a factor of 10 as the harmonic ratio ascends by whole integers.

Exercises:

1. Assign the same Rate Scaling value to each operator so that time-delays for entrances of the harmonics vary according to the highness or lowness of the key depressed. Try several different "across-the-board" values.
2. Try adjusting the EG for Ops. 2-6 to give the illusion of closing a low-pass filter. **Hint:** Put all Level 3 and Level 4 settings for Ops. 2-6 to "0" then adjust the Rate 2 settings so they read something like 20, 25, 30, 35, 40.

On/Off	1 Car <input checked="" type="checkbox"/>	2 Car <input checked="" type="checkbox"/>	3 Car <input checked="" type="checkbox"/>	4 Car <input checked="" type="checkbox"/>	5 Car <input checked="" type="checkbox"/>	6 Car <input checked="" type="checkbox"/>	
EGRate	99 99 99 99	80 99 99 99	70 99 99 99	60 99 99 99	50 99 99 99	40 99 99 99	
EGLev	99 99 99 0	99 99 99 0	99 99 99 0	99 99 99 0	99 99 99 0	99 99 99 0	
Scaling	0 A-1 0						
Curve	-lin -lin						
Output Level	99 Vel RSc AM 0 0 0						
Freq	M Coar Fine Det r 1. 00 0	M Coar Fine Det r 2. 00 0	M Coar Fine Det r 3. 00 0	M Coar Fine Det r 4. 00 0	M Coar Fine Det r 5. 00 0	M Coar Fine Det r 6. 00 0	
PEGRat	99 99 99 99	LFO Wave Spd Del PMD AMD PMS Sync			File: DX-7 Demos		MIDI TstKV
PEGLev	50 50 50 50	Triangl	0 0 0 0 0 0	On	23: AddSynth 4		1 64

Algorithm	32	Operator 6 Envelope	Rate 99 <input checked="" type="checkbox"/>	Rate 0 <input type="checkbox"/>						
<table border="1"> <tr> <td>3</td> <td>4</td> <td>6</td> </tr> <tr> <td>1</td> <td>2</td> <td>5</td> </tr> </table>	3	4	6	1	2	5				
3	4	6								
1	2	5								
KeyTP	C3									
Feedback	0									
KeySync	On									

24: Addsynth 5

General Description:

This voice, too, is derived from Addsynth 1 and shares an identical steady-state sound with it. It also shares with Addsynth 4 the concept of harmonics fading in one by one over a period of time. The differences this time are that the harmonics enter in opposite order, from high to low, and take longer to enter. This is of course similar to opening up a high-pass filter.

Patch Information:

Identical to Addsynth 1, except EG Rate 1 settings for Ops. 1-6 ascend from 15 to 70 as the harmonic ratio ascends by whole integers.

Exercises:

1. Assign the same Rate Scaling value to each operator so that time-delays for entrances of the harmonics vary according to the highness or lowness of the key depressed. Try several different "across-the-board" values.
2. Try adjusting the EG for Ops. 2-6 to give the illusion of sweeping the center-frequency of a band-pass filter from high to low. Hint: Put all Level 3 and Level 4 settings for Ops. 2-6 to "0" then adjust the Rate 2 settings so they read something like 30, 35, 40, 45, 50.

On/Off	1 Car <input checked="" type="checkbox"/>				2 Car <input checked="" type="checkbox"/>				3 Car <input checked="" type="checkbox"/>				4 Car <input checked="" type="checkbox"/>				5 Car <input checked="" type="checkbox"/>				6 Car <input checked="" type="checkbox"/>			
EGRate	15 99 99 99				20 99 99 99				25 99 99 99				30 99 99 99				40 99 99 99				70 99 99 99			
EGLev	99 99 99 0				99 99 99 0				99 99 99 0				99 99 99 0				99 99 99 0				99 99 99 0			
Scaling	0 A-1 0				0 A-1 0																			
Curve	-lin		-lin		-lin																			
Output Level	99		Vel RSc AM		99																			
	0		0 0		0		0 0		0		0 0		0		0 0		0		0 0		0			
Freq	M Coar Fine Det				M Coar Fine Det																			
	r 1. 00 0				r 2. 00 0				r 3. 00 0				r 4. 00 0				r 5. 00 0				r 6. 00 0			
PEGRat	99 99 99 99				LFO Wave Spd Del PMD AMD PMS Sync				File: DX-7 Demos				MIDI TstKV											
PEGLev	50 50 50 50				Triangl 0 0 0 0 0 0 On				24: AddSynth 5				1 64											

Algorithm	32	Operator 1 Envelope	Rate 99 <input checked="" type="checkbox"/>	Rate 0 <input type="checkbox"/>
KeyTP	C3			
Feedback	0			
KeySync	On			

Expressive Pitch Bend with Timbre Variation

On many acoustic instruments, expressive pitch bending also results in changes timbre (or tone color). Often (as in a saxophone or harmonica, for example) it is a matter of losing some of the original brilliance or edginess of the sound as the pitch is bent downward. This effect can be achieved on a synthesizer with a dedicated pitch wheel, such as the DX series of keyboards, only by incorporating simultaneous and parallel use of another controller. I experimented with the Pitch Wheel in various combinations with the Breath Controller, Foot Pedal and After Touch, but was not quite satisfied. The results were often interesting, but not very "natural-sounding," because even after much practice it was still difficult to achieve the necessary degree of physical coordination. Though it first seemed the least likely prospect (my left hand was already busy with the Pitch Wheel at the time, right?), I have settled on the Mod Wheel as the easiest, surest way to coordinate changes of timbre with pitch bend. Achieving the best results with this effect requires cultivating a two-fingered, dual-wheel technique with your left hand and a little minor reprogramming of the patches you want to use. The dual-wheel technique involves using the index finger on the Mod Wheel and the middle finger on the Pitch Wheel, each doing exactly the same thing at the same time. The reprogramming is necessary so that the timbre will be "normalized" when the Mod Wheel is half way up. It also compensates for the reduced sweep of the Mod Wheel from the half-way point down to minimum-- which coincides with the most frequently used pitch bend range (i.e. from middle, or "0" on down) for instruments such as harmonica and saxophone. To reprogram a patch for use with this technique, simply follow these steps.

1. Choose an existing patch or timbre and determine which operators are carriers and which are modifiers. For our tutorial example let's use the original DX7 factory ACCORDION preset. It uses algorithm 4, which means that operators #1 and #4 are both carriers and operators #2, #3, #5, and #6 are all modifiers. (I know the accordion is not noted for its expressive pitch bends, but by the time we're through it'll make a dandy harmonica patch.)
2. Determine which modulating operators feed directly into a carrier and program them for amplitude modulation sensitivity. (On the DX7, enter the edit mode and press button 16; on the DX7II, enter the edit mode, press button 11, and move the cursor over to the "Ams" column. Then select the specific operators you wish to program.) In the ACCORDION preset, operators #2 and #5 are the modifiers which feed directly into the carriers. Program these modulators so they each have an amplitude modulation sensitivity setting of "2."
3. Now, program the Mod Wheel so that it will control only E.G. Bias with maximum range sensitivity. This may require removing pitch modulation (vibrato) or amplitude modulation (tremolo) from Mod Wheel control. (On the DX7, while in the function mode, buttons 17, 18, 19, and 20 will allow you to program this: Range should be "99", Pitch and Amplitude should be "OFF" while E.G. Bias should be "ON." On the DX7II, enter the edit mode and press button 25 repeatedly until "Modulation wheel" appears in the upper left of the edit window: Pmod should be "0," Amod should be "0," and Egbias should be "99.") If you want to be able to control vibrato/tremolo effects, too, as I usually do, then I'd recommend programming After Touch to control these.

At this point, push the Mod Wheel all the way up and listen to the sound of the patch you are working with. It should sound the same as it did before you started. When you return the mod wheel to "0" you should get a much darker sound.

4. Next, place the Mod Wheel exactly in the middle of its range (so its finger groove lines up with the pitch wheel finger groove).
5. If you are modifying the ACCORDION patch, adjust the operator outputs as follows: Operator #2 goes from "79" to "81"; Operator #5 goes from "70" to "75." (On the DX7, in the edit mode, press button 27. On the DX7II, enter the edit mode and press button 10 once or twice until you read ">Level" in the edit window.) This is done so that when the two wheels are used together with notches aligned, the patch will have its original timbre when the pitch wheel is at "0."

If you are using a different starting patch, simply go to the modulating operators on which you set up Mod Wheel control and begin nudging their output values upward while testing the audio results by playing on the keyboard. Keep experimenting until the voice sounds more or less the way it originally did. Hint: tweak each output level a little before going too far with one operator.

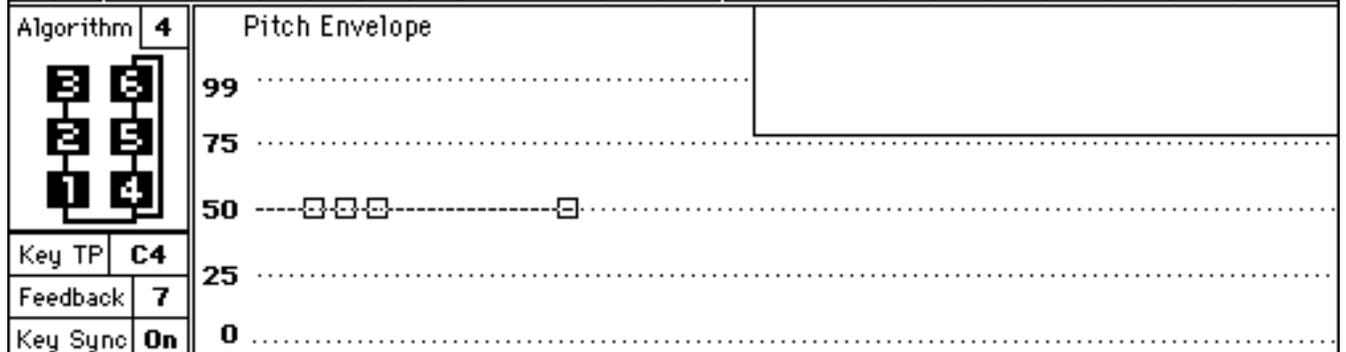
Now you can use your index and middle fingers together to control pitch bend and timbre simultaneously by moving the two wheels together. Using pitch bends in the minus range with parallel movements of the Mod Wheel will vary the patch's timbre between its original sound and one several shades darker in direct correlation to the amount of pitch bend. With only a couple of practice sessions I think you will find that moving the two fingers in tandem becomes second nature and only slightly more physically demanding than working only the pitch bend wheel. The resulting sound, however, is much more interesting and expressive than mere pitch bend!

Extras. I find that a pitch bend range of "1 or 2" (half or whole step) works best to give natural sounding bends while still creating effective timbre changes when the two wheels are used together. Also for this particular patch, I set up After Touch to activate a somewhat exaggerated tremolo/vibrato effect using a rather fast LFO speed setting (ca. 45). On a DX7, set a comfortable After Touch range for your playing style and simply turn on the Pitch Mod and Amplitude Mod options. On a DX7II, where it's possible to make such distinctions, I might use about twice as much amplitude modulation or tremolo (ca."60") as pitch modulation or vibrato (ca."30"). Other suggested modifications for this particular patch below:

- A. Get rid of the very slow "beats" created by the extreme detuning of operators #2 and #3. (Adjust detuning values of "+0" for operators #2 and #3. Or you might desire to leave in a subtle detuning effect by setting operator #3 to ca. "+3" instead of "0.")
- B. Raise the sustain levels of the modifying operators (especially #5 and #6) so that the Mod Wheel can exercise stronger control over the timbre of long-held notes. (Once the E.G.'s reach the lower sustain levels on a long-held note, you cannot raise the output above those levels with the Mod Wheel.)

		19: ACCORDION				Yamaha DX7: ROM-3B					
On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Mod <input checked="" type="checkbox"/>	4 Car <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>					
Output Level	83 Vel RSc AM 0 0 0	79 Vel RSc AM 0 0 0	52 Vel RSc AM 0 0 0	86 Vel RSc AM 0 0 0	70 Vel RSc AM 0 0 0	57 Vel RSc AM 0 0 0					

		4: Accordion2				DX7 II Voices: Utility2				ID 1				
On/Off	1 Car <input checked="" type="checkbox"/>	2 Mod <input checked="" type="checkbox"/>	3 Mod <input checked="" type="checkbox"/>	4 Car <input checked="" type="checkbox"/>	5 Mod <input checked="" type="checkbox"/>	6 Mod <input checked="" type="checkbox"/>								
EGRate														
EGLev														
Scaling														
Curve														
Output Level	83 Vel RSc AM 0 0 0	79 Vel RSc AM 0 0 2	52 Vel RSc AM 0 0 0	86 Vel RSc AM 0 0 0	75 Vel RSc AM 0 0 2	60 Vel RSc AM 0 0 2								
Freq	M Coar Fine Det r . 50 0	M Coar Fine Det r 1. 00 +6	M Coar Fine Det r 3. 00 +7	M Coar Fine Det r 1. 00 0	M Coar Fine Det r . 50 -1	M Coar Fine Det r 6. 00 +1								
Pitch Rate	84	95	95	60	Range Vel RSc		LFO Wave	Spd	Del	PMD	AMD	PMS	Sync	Mode
EG Lev	50	50	50	50	8 Oct	Off	0		45	0	0	0	1	Off Single



Addendum/Update for Basic FM Synthesis booklet

Though the demos in this booklet were written for the original DX7, the concepts behind these demo sounds are applicable to any Yamaha FM synthesizer. All of the actual patches in the booklet are completely compatible with any 6-operator FM synthesizer such as the TX7, DX7II, TX802, SY77 (which are all available in both studios at O.U.). In fact since many of the demos use only two sine wave operators, they can be duplicated on 4-operator synthesizer such as the TX81Z and the V50 which are also available to students at O.U.

Yamaha DX7 IIFD

Since the DX7 II-FD has the benefit of a disk drive which allows you to load the sounds directly into the synthesizer, without a computer or other software, you may want to begin your exploration of these demos on this synthesizer.

Steps for exploring Basic FM Synthesis on the Yamaha DX7 IIFD:

1. Push the button labeled "EDIT" to the left of the display screen.
2. Push the button #14 under the "UTILITY" menu (you *may* need to push it repeatedly) until the top line reads: ">Master tuning Memory Protect >INT >CRT"
3. Use the CURSOR buttons at the far upper left of the DX7II to move the cursor to the arrow (>) in front of "INT" (which stands for "Internal")
4. Push the "- 1/OFF" button to turn the internal memory protect off.
5. Insert the disk containing the demos into the drive at the far left corner of the DX7II. (It may be there already, so you may wish to jump to the next step.)
6. Push the button #16 under the "DISK" menu (you may need to push it repeatedly) until the top line read says: "DISK INT >DIR >SAVE etc.
7. Push the CURSOR buttons to move the cursor to the arrow (>) in front of "DIR" (which stands for Directory) and push the "+1/Yes" button
8. Press the "- 1/OFF" and/or the "+1/Yes" buttons until you see the file name "fm-demos" on the bottom line.
9. Press the right arrow cursor two times so that the cursor is at the arrow (>) in front of "Load" — then press the "+1/Yes" two times.
10. Press the "SINGLE" button (which should have a red light above it. HOWEVER—If the red light above the "PERFORMANCE" button is on then press that button first, then the "SINGLE" button.
11. Now you will be able to simply press the button corresponding to the specific demo you wish to examine. (Be sure that there is no red light above the "1-32" button or you will be selecting patches 33-64 instead of 1-32. If the red light is on simply push the button and it will go off.)